

Clean copy of allowed claims

1. A reliable symbol identification method for use in a communication system for transmitting symbols of a high order constellation comprising:

calculating a reliability factor of a captured sample from values of a plurality of samples in proximity to the captured sample, wherein the captured sample and the plurality of other samples represent a data signal received from a communication channel, and

if the reliability factor is less than a predetermined limit, designating the captured sample as a reliable symbol.

2. The method of claim 1, wherein the reliability factor R_n of the captured sample is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_n , is the captured sample,

y_{n-i} is a sample in proximity to the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

3. The method of claim 2, where $c_i = 1$ for all i .

4. The method of claim 2, wherein $K_1 = 0$.

5. The method of claim 2, wherein $K_2 = 0$.
6. The method of claim 1, wherein the predetermined limit varies over time.
7. The method of claim 1, further comprising determining a rate at which reliable symbols are identified, and
if the rate is less than a predetermined value, increasing the predetermined limit.
8. The method of claim 1, further comprising determining a rate at which reliable symbols are identified, and
if the rate exceeds a second predetermined value, decreasing the predetermined limit.
9. The method of claim 1, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1n-i}^2 + y_{2n-i}^2}) c_i$$
, where
 y_{1n-i} and y_{2n-i} respectively represent values of a neighboring sample y_{n-i} in first second dimensions,
 K_1, K_2 are numbers of samples adjacent to the candidate sample, and
 c_i is a coefficient representing any prior knowledge of intersymbol interference effects.
10. A method of identifying reliable symbols for use in a communication system for transmitting symbols of a high order constellation, comprising:

for a captured sample y_n recovered from a communication channel;

initially setting a reliability factor to zero;

iteratively, for $i = -K_1$ to K_2 , $i \neq 0$, wherein K_1, K_2 are real numbers:

adding to the reliability factor a value based on another captured sample y_{n-i} also recovered from the communication channel,

if the reliability factor exceeds a predetermined limit, disqualifying the captured sample as a reliable symbol,

otherwise, incrementing i and, if $i=0$, re-incrementing i for a subsequent iteration; and

thereafter, unless the captured symbol has been disqualified, designating the captured sample as a reliable symbol.

11. The method of claim 10, wherein the adding adds an absolute value of the sample y_{n-i} to the reliability factor.

12. The method of claim 10, wherein the adding adds a scaled value of the sample y_{n-i} to the reliability factor, the value scaled in accordance with a coefficient c_i , representing any prior knowledge of intersymbol interference effects.

13. The method of claim 10, wherein the adding adds the power of the sample y_{n-i} to the reliability factor.

14. The method of claim 10, wherein the predetermined limit is half a width of an annular constellation ring in which the captured sample is observed.

15. The method of claim 10, wherein the predetermined limit is $(K_1 + K_2) d_{\min}$, where d_{\min} is half a distance between two constellation points that are closest together in a governing constellation.

16. The method of claim 10, wherein the predetermined limit varies over time.

17. The method of claim 10, further comprising determining a rate at which reliable symbols are identified, and
if the rate is less than a predetermined value, increasing the predetermined limit.

18. The method of claim 10, further comprising determining a rate at which reliable symbols are identified, and
if the rate exceeds a second predetermined value, decreasing the predetermined limit.

19. A method of identifying reliable symbols, for use in a communication system for transmitting symbols of a high order constellation comprising:

for a captured sample recovered from a communication channel:

determining whether any value of a plurality of neighboring samples also recovered from the communication channel is within a predetermined limit, and

if none of the values exceed the predetermined limit, designating the captured sample as a reliable symbol.

20. The method of claim 19, wherein the predetermined limit varies over time.
21. The method of claim 19, further comprising:
determining a rate at which reliable symbols are identified, and
if the rate is less than a predetermined threshold, increasing the predetermined limit.
22. The method of claim 21, further comprising, if the rate exceeds a second predetermined threshold, decreasing the predetermined limit.
23. The method of claim 19, wherein the plurality of neighboring samples occur in a first window adjacent to the captured sample on one side of the captured sample.
24. The method of claim 19, wherein the plurality of neighboring samples occur in a pair of windows that are adjacent to, and on either side of the captured sample.
25. A method of detecting reliable symbols within a sample data signal for use at a receiver of a communication system for transmitting symbols of a high order constellation, comprising:
identifying a sequence of sample values having values within a predetermined limit,
and
designating a sample adjacent to the sequence as a reliable symbol.
26. The method of claim 25, wherein the predetermined limit varies over time.

27. The method of claim 25, further comprising:

determining a rate at which reliable symbols are identified, and

if the rate is less than a predetermined threshold, increasing the predetermined limit.

28. The method of claim 27, further comprising, if the rate exceeds a second

predetermined threshold, decreasing the predetermined limit.

29. A data decoder for use in a communication system for transmitting symbols of a high order constellation comprising:

a reliable symbol detector to detect reliable symbols from a sequence of captured samples, the reliable symbols being the captured samples which are estimated to be located in a correct decision region of a corresponding source symbol,

an adaptation unit coupled to the reliable symbol detector to generate intersymbol interference (ISI) metrics based on the reliable symbols, and

a data decoder to receive the captured samples and estimate source symbols based on the ISI metrics.

30. An equalization method for use in a communication system for transmitting symbols of a high order constellation, comprising;

identifying reliable symbols from a string of captured samples recovered from a communication channel, the reliable symbols being the captured samples which are estimated to be located in a correct decision region of their corresponding source symbols,

calculating the channel effects based on the reliable symbols and samples adjacent thereto,

correcting the captured samples based on calculated channel effects to equalize the string of captured samples.

31. The method of claim 30, wherein the identifying comprises:

calculating a reliability factor of a captured sample from values of a plurality of samples in the neighborhood of the captured sample,

if the reliability factor is below a predetermined limit, designating the captured sample as a reliable symbol.

32. The method of claim 31, wherein the reliability factor of the captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_{n-i} is a sample in the neighborhood of the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

33. The method of claim 31, wherein the reliability factor of the captured sample y_n is given by:

$$R_n = \sum_{i=-1}^K |y_{n-i}| c_i, \text{ where}$$

y_{n-i} is a sample in the neighborhood of the captured sample,
 K is a length of samples, and
 c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

34. The method of claim 31, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1n-i}^2 + y_{2n-i}^2}) c_i, \text{ where}$$

y_{1n-i} and y_{2n-i} respectively represent values of a neighboring sample y_{n-i} in first second dimensions,

K_1, K_2 are numbers of samples adjacent to the captured sample, and
 c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

35. The method of claim 30, wherein the identifying comprises:
identifying a sequence of samples having received signal magnitude levels below a predetermined limit, and
designating a sample adjacent to the sequence as a reliable symbol.

36. The method of claim 30, wherein, for QAM transmission, the identifying comprises:
identifying a sequence of samples for which a received signal magnitude in a quadrature-phase component is below a predetermined limit, and

designating an adjacent sample as a reliable symbol for quadrature-phase.

37. The method of claim 30, wherein, for QAM transmission, the identifying comprises:

identifying a sequence of samples for which a received signal magnitude in an in-phase component is below a predetermined limit, and

designating an adjacent sample as a reliable symbol for in-phase.

38. The method of claim 30, wherein the calculating estimates K channel coefficients a_i according to a least squared error analysis of $y_{RS} - \hat{x}_n - \sum_{i=1}^K \hat{a}_i \hat{x}_{n-i}$, solving for \hat{a}_i for a plurality of reliable symbols y_{RS} , where \hat{x}_n and \hat{x}_{n-i} are estimated transmitted symbols.

39. The method of claim 30, further comprising assigning weights among the reliable symbols based upon respective reliability factors.

40. An equalizer for use in a communication system for transmitting symbols of a high order constellation, comprising:

a buffer memory,

a reliable symbol detector in communication with the buffer memory, the detector to estimate which samples from a sequence of captured samples are located in a correct decision region of their corresponding source symbols,

an adaptation unit in communication with the reliable symbol detector to estimate channel effects based on values of the reliable symbols and samples adjacent thereto, and a symbol decoder in communication with the adaptation unit and the buffer memory.

41. The equalizer of claim 40, wherein the reliable symbol operates according to a method, comprising:

calculating a reliability factor of a captured sample from values of a plurality of samples proximate to the captured sample, and

if the reliability factor is less than a predetermined limit, designating the captured sample as a reliable symbol.

42. The equalizer of claim 41, wherein the reliability factor R_n of the candidate sample is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_n , is the captured sample,

y_{n-i} is a sample in proximity to the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

43. The equalizer of claim 41, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1-n-i}^2 + y_{2-n-i}^2}) c_i, \text{ where}$$

$y_{1_{n-i}}$ and $y_{2_{n-i}}$ respectively represent values of a neighboring sample y_{n-i} in first second dimensions,

K_1 , K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

44. A receiver for use in a communication system for transmitting symbols of a high order constellation, comprising:

a demodulator to sample and capture transmitted data from a channel,

a buffer memory in communication with the demodulator to store the values of captured samples,

a processor, executing instructions that establish the following logical structures therein:

a reliable symbol detector in communication with the buffer memory to identify which of the stored captured samples are likely to be located in a correct decision region of their corresponding source symbols,

an adaptation unit in communication with the reliable symbol detector to estimate channel effects from the values of the reliable symbols, and

a symbol decoder unit in communication with the adaptation unit and the buffer memory.

45. The receiver of claim 44, wherein the reliable symbol operates according to a method, comprising:

calculating a reliability factor of a captured sample from values of a plurality of samples proximate to the captured sample, and

if the reliability factor is less than a predetermined limit, designating the captured sample as a reliable symbol.

46. The receiver of claim 45, wherein the reliability factor R_n of the captured sample is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_n , is the captured sample,

y_{n-i} is a sample in proximity to the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

47. The receiver of claim 45, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1n-i}^2 + y_{2n-i}^2}) c_i, \text{ where}$$

y_{1n-i} and y_{2n-i} respectively represent values of a neighboring sample y_{n-i} in first second dimensions,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

48. The receiver of claim 44, further comprising a second buffer memory in communication with the symbol decoder.

49. A data communication system for transmitting symbols of a high order constellation comprising:

a source that transmits data encoded as symbols, the symbols being selected from a high-order constellation,

a destination that captures a signal representing the transmitted symbols having been corrupted by at least intersymbol interference, the destination:

identifying reliable symbols from the captured samples, the reliable symbols being those captured samples that are estimated to be located in a correct decision region of their corresponding source symbols,

calculating channel effects based on the reliable symbols and samples proximate thereto, and

correcting other captured samples based on the channel effects.

50. The system of claim 49, wherein reliable symbols are identified according to a method comprising:

calculating a reliability factor of a captured sample from values of a plurality of samples proximate to the captured sample, and

if the reliability factor is less than a predetermined limit, designating the captured sample as a reliable symbol.

51. The system of claim 50, wherein the reliability factor R_n of the captured sample is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_n , is the captured sample,

y_{n-i} is a sample in proximity to the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

52. The system of claim 50, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1n-i}^2 + y_{2n-i}^2}) c_i, \text{ where}$$

y_{1n-i} and y_{2n-i} respectively represent values of a neighboring sample y_{n-i} in first second dimensions,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

53. A computer readable recording medium having stored thereon instructions that, when executed, cause a processor to identify reliable symbols from captured samples received by a system for use in communicating data via a high order constellation by a process comprising:

calculating a reliability factor of a captured sample from values of a plurality of samples proximate to the captured sample, and

if the reliability factor is less than a predetermined limit, designating the captured sample as a reliable symbol.

54. The medium of claim 53, wherein the reliability factor R_n of the captured sample is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} |y_{n-i}| c_i, \text{ where}$$

y_n , is the captured sample,

y_{n-i} is a sample in proximity to the captured sample,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

55. The medium of claim 53, wherein the reliability of a two-dimensional captured sample y_n is given by:

$$R_n = \sum_{i=-K_1, i \neq 0}^{K_2} (\sqrt{y_{1n-i}^2 + y_{2n-i}^2}) c_i, \text{ where}$$

y_{1n-i} and y_{2n-i} respectively represent values of a neighboring sample y_{n-i} in first second dimensions,

K_1, K_2 are numbers of samples adjacent to the captured sample, and

c_i is a coefficient representing any prior knowledge of intersymbol interference effects.

56. A computer readable recording medium having stored thereon instructions that, when executed, cause a processor to correct channel effects in captured samples received by a system for use in communicating data via a high order constellation by a process comprising:

identifying reliable symbols from a string of captured samples, the reliable symbols being the captured samples which are estimated to be located in a correct decision region of their corresponding source symbols,

calculating channel effects based on the reliable symbols and samples proximate thereto, and

correcting the captured samples based on the channel effects.

57. A method for transmitting symbols of a high order constellation, of decoding a string of captured samples recovered from a communication channel comprising:

identifying reliable symbols from the string of captured samples, the reliable symbols being the captured samples which are estimated to be located in a correct decision region of their corresponding source symbols,

calculating channel effects based on the reliable symbols and samples proximate thereto,

estimating transmitted symbols from remaining captured samples based on the channel effects, and

outputting the estimated symbols as a decoded data signal.